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File Code: 3420
Date: September 3, 2008

Bruce Bauer
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Dear Bruce:

Enclosed is the report, "Santa Clara Canyon 2007 Douglas-fir Tussock Moth Suppression Project Using TM-Biocontrol-1 Virus, Santa Clara Pueblo, New Mexico" prepared by Terrence J. Rogers and Debra Allen-Reid. We enjoyed working with you and your staff on this successful application of the tussock moth virus. Please feel free to contact us should you have questions about the report, or if we can be of any further assistance.

Sincerely,

/s/ Debra Allen-Reid
DEBRA ALLEN-REID
New Mexico Zone Leader, Forest Health

Enclosure

cc: Alan Quan
Allen White
John Anhold
Iral Ragenovich
Richard C Reardon
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Hardcopy to:
John Waconda, BIA Regional Forester, Southwest Region

United States
Department of
Agriculture

Forest
Service

**Southwestern
Region**

Forestry
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Health

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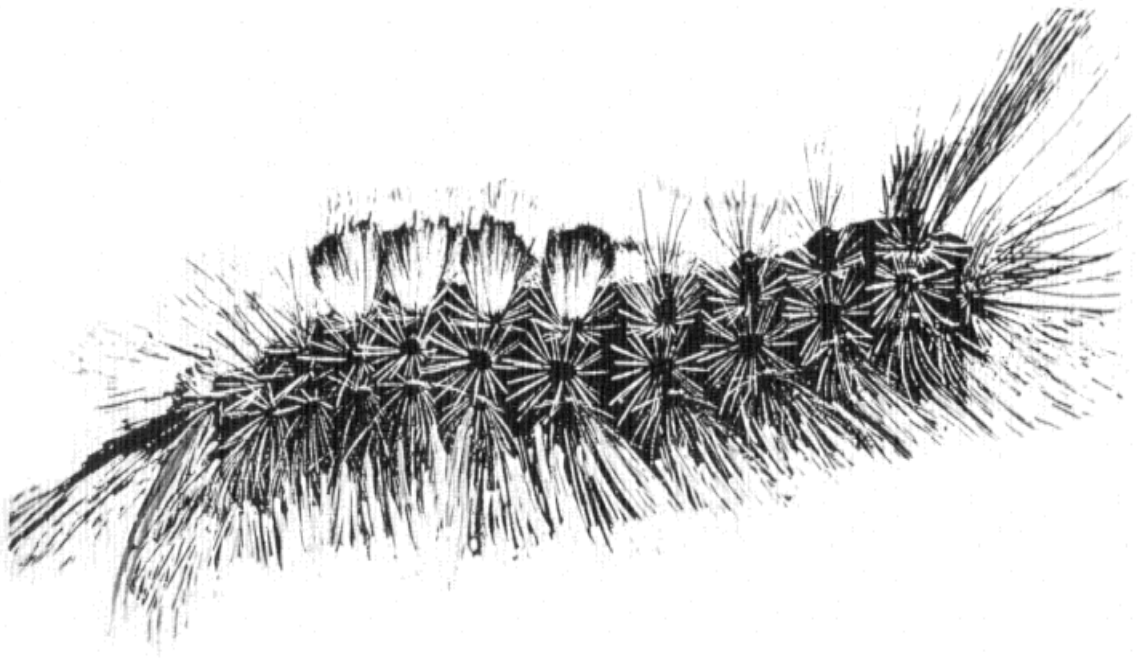
Santa Clara Canyon 2007 Douglas-fir Tussock Moth Suppression Project, Santa Clara Pueblo

February 2008

Terrence J. Rogers and Debra Allen Reed



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Introduction

In April 2007, Douglas-fir tussock moth (DFTM) , *Orgyia pseudotsugata,* egg masses were discovered on the Santa Clara Pueblo in Santa Clara Canyon This is the first time in 28 years that the tussock moth has been detected in the Jemez Mountains. In 1974, 1975, and 1976, outbreaks of the DFTM in the Jemez Mountains were suppressed to low levels using various formulations of the biological insecticide, *Bacillus thuringiensis* Kurstaki (Lessard, Gene and David G. Holland, 1985). As a result of this recent tussock moth egg mass discovery, a sequential egg mass survey (Appendix A) was conducted on May 1, 2007 to determine the status of tussock moth populations in Santa Clara Canyon. The results of this sequential egg mass survey (refer to our 3420 letter of May 9, 2007) revealed tussock egg masses were very abundant and that defoliation would be severe

with some top-killing and tree mortality. The results of this survey are summarized in Figure 1, Appendix A.

Results of the DFTM egg mass survey along with treatment options were provided to the Division of Forestry, Santa Clara Pueblo. Because the tussock moth infestation was located along Santa Clara Creek and several fishing ponds, treatment options were limited to microbial controls such as TM-Biocontrol, a nucleopolyhedrosis virus, and the bacterium, *Bacillus thuringiensis* Kurstaki. Based on the results of the egg mass survey, the Santa Clara Pueblo Tribal Counsel and its members chose to implement a suppression strategy using the virus, TM-Biocontrol. This option was chosen because it is ecologically more environmentally friendly, and host specific to DFTM caterpillars.

Douglas-fir trees are of special importance to the Pueblo of Santa Clara and several other surrounding Pueblos as well. The branches are collected and commonly used in many cultural and traditional ceremonies by the Pueblo.

To avoid lengthy delays involved in doing an Environmental Assessment, the Santa Clara Tribal Counsel declared Sovereign Immunity and engaged a full-service aerial applicator to provide all aircraft support and application needs and assumed the cost of the contract and carrier for the virus.

Under a "Participating Agreement between the USDA Forest Service, Southwestern Region and the Santa Clara Pueblo", the Forest Service provided the Tribe 1200 acre-equivalents of the TM-Biocontrol virus and provided technical assistance for proper handling and application of the material. No Federal funds were used to fund the cost of the project.

Objectives

The objectives of this project were to; (1) reduce the DFTM population to low levels so they could be regulated by their natural controls (predators, parasites and diseases); and (2) to prevent their spread on to adjacent, uninfested lands.

Project Area

The project area is located in the upper portions of Santa Clara Canyon in the mixed conifer forest cover type. The Canyon, valued for its recreational opportunities, is a deep tree line-lined retreat with several mountain-ringed fishing ponds, camp sites, and picnic areas. Elevations rise to over 10,000 feet. Initially, when the tussock moth was first detected, Tribal forestry wanted to spray all of the mixed conifer type in the Canyon totaling approximately 10,000 acres. Later based on GPS points on where it began and ended, and assuming the outbreak went to the top of the Canyon, the proposed treatment area decreased to 3000 acres. With too many unknowns and with limited funding it was decided to walk and GPS the entire extent of the outbreak area which resulted in a further reduction to 1,130 acres. Since there were no other areas infested with tussock moth nearby, a control block was not available to adjust for natural larval mortality.

Monitoring Egg Mass Hatch, Larval Dispersal, and Timing of Application

The use of degree-day accumulation (Appendix A) was used to monitor egg mass hatch, larval dispersal, and time spray application. The relationship between accumulation of degree-days and insect-host phenology was used to predict timing of eclosion, larval dispersal, and spray date in 1976 and 1979. Lessard and Holland (1985), using accumulation of degree-day data from *Bacillus thuringiensis* Kurstaki field experiments near Los Alamos in 1974 and 1975 showed that egg hatch was complete and larval dispersal and development optimal at ca. 500 degree-days. Since Santa Clara Canyon is approximately 6 miles north of Los Alamos, 500 degree days was also chosen as the time to initiate the spray project on the Santa Clara Pueblo.

Prespray and Postspray Larval Surveys

Prespray and Postspray larval surveys (Appendix A) were conducted to evaluate project effectiveness. Prespray surveys were conducted the day before treatment was to begin and Postspray surveys 14 days (June 28, 2007) and 25 days (July 9, 2007) after treatment.

Spray Application

Deb, you have the info on this. The Safety, Communication Plans etc. can be put in Appendix B

Spray Deposit Monitoring

White Kromecote cards placed in plastic card holders were used to monitor spray deposit. In the morning, just prior to the spray application, twenty-four cards were place at twelve locations along the Canyon. Two sets of card were also placed outside the treatment area on the east and west ends to check for drift. The cards, two per location, were placed in clearings .2 to .4 miles apart along the Canyon.

Results

Timing of Virus Application

As previously indicated timing of virus application was based (1) DFTM egg hatch and (2) dispersal of the first instars from the egg masses onto the foliage which were optimal at ca. 500 degree-days. On May 30, 535 degree-days had accumulated. The actual spray date, however, was June 14, 2007 at which time over 1,291 degree-days had accumulated. Timing of treatment was delayed because of (1) delays in the procurement and shipping of the carrier and (2) because the Canyon was closed during the week of May 28, 2007 because of Tribal cultural events.

Spray Deposit Monitoring

Spray recovery on the Kromecote cards was good to excellent on twenty of the 24 card placed along the Canyon to monitor spray application. Cards placed at the 4.5 and 5.1 mile points of the Canyon were blank. Either this portion of the treatment area was not sprayed, or the cards were placed in areas that were blocked from the spray. Overall, the Kromecote cards show the spray application was successfully applied to the treatment area. Since the cards placed outside the treatment area were also blank, there appears to have no spray drift from the area treated.

Larval Population Densities

DFTM larval population densities sampled 15 days after treatment (Figure 3, Appendix A) remained relatively unchanged from Prespray densities (Figure 2, Appendix A). Caterpillars sampled 14 days after treatment were a mix of 3rd, 4th, 5th, and, 6th instars. The caterpillars were active and showed no signs of virus infection. A few dead, virus-killed tussock moth caterpillars were found hanging from the branches of a several host trees.

DFTM larval densities 25 days after treatment were variable. Larval densities decreased slightly in the lower half of the treatment area, but increased in the upper portions of the treatment area (Figure 3, Appendix A). Although there was a significant increase in the number of virus-killed caterpillars 25 days after treatment, there were still large numbers of tussock moth caterpillars actively feeding at all of the plots sampled. Because there is a five- to eight week incubation period after virus application before the larvae stop feeding, the virus may just started to become contagious. Approximately 250-300 active, sick and dead DFTM caterpillars were collected and sent to Imre Otvos of the Canadian Forest Service, Natural Resources, Pacific Forestry, B.C, Canada to be bio-assayed for virus contamination. A total of 190 caterpillars were bio-assayed and all of them were found to be infected with TM-Biocontrol. These bio-assay results indicate the virus may have been starting to exert control.

Defoliation

Because viruses are slow acting and feeding is not inhibited until the larvae are close to pupation, there was no foliage protection achieved in Santa Clare Canyon during year of treatment. As the egg mass data collected in the spring of 2007 predicted (Figure 1, Appendix A), defoliation was heavy (Figures 5 and 6 below). Some top-killing and tree mortality is also expected to occur. Defoliation was heaviest along the eastern half of the Canyon.

Figure 5. Aerial view of DFTM defoliation, Santa Clara Canyon 2007

Figure 6. DFTM defoliation, Santa Clara Canyon, 2007

Pheromone Trapping Survey

Because large numbers of caterpillars were still present in the Canyon 25 days after treatment, pheromone traps were placed at 7 of the 10 plots sampled to monitor DFTM population levels. Four traps were placed at plots 1, 2, and 3 and two traps were placed at plots 4, 5, 6, and 7. The traps were deployed on July 9, 2007 and collected on October 18, 2007. The trapping results are summarized in Table 7 below:

Figure 7. Santa Clara Canyon Pheromone Trapping Resuls 2007

Plot #	Trap 1	Trap 2	Trap 3	Trap 4	Average
1	43	12	24	32	27.75
2	20	11	8	11	12.5
3	35	12	44	27	29.5
4	4	0	na	na	2
5	7	12	na	na	9.5
6	4	26	na	na	15
7	2	5	na	na	3.5
			treatment	Block Average	14.25

Pheromone traps are used as part of an early warning system used to detect outbreaks of the DFTM. This survey uses sticky traps baited with a synthetic version of the female moth sex attractant or pheromone. The number of male moths captured in late summer and early fall during the mating season is used as an early warning indicator of future defoliation trends. When average trap catches reach 25 or more male moths, defoliation is expected to occur within the next 1 to 3 years. The DFTM early warning system traps are not calibrated for use during an actual tussock moth outbreak (Ragenovich, 2004). As tussock moth populations increase, a decline in trap catches is typically noted since the

baits used in the traps is 1000 times weaker than that produced by the female tussock moth. Male moth trap catches, however, were high in several of the traps and trap averages exceeded the 25 moths per trap threshold level at two of the seven plots sampled where tussock moth populations were heaviest. Plots 4 through 7 were located in the upper portions of the Canyon tussock moth populations and defoliation was barely detectable. These trapping results may indicate the virus treatment may have successfully collapsed the outbreak in Santa Clara Canyon.

Fall Egg Mass Surveys

A fall egg mass survey conducted at the time the pheromone traps were collected last fall also support the collapse of the outbreak. A total of 36 egg masses were collected. Although tussock moth egg masses were abundant in the spring of 2007, no new egg masses were found in the fall of 2007.

Conclusions

1. The spray deposit cards placed along the Canyon showed the virus application was successfully applied.

2. The results of our Postspray larval surveys were inconclusive. Large numbers of DFTM were still actively feeding 25 days after treatment.

3. Based on the bio-assays conducted by the Canadian Forest Service, Natural Resources/Canada, Pacific Forestry, the virus, TM-Biocontrol, may have been increasing to epizootic levels 25 days after treatment.

4. Because viruses are slow acting and feeding is not inhibited until the larvae are close to pupation, there was no foliage protection achieved in Santa Clare Canyon during year of treatment.

5. Male tussock moth trap catches from pheromone traps deployed 25 days after treatment and the absence of new egg masses collected in the fall of 2007 suggests TM-Biocontrol was successful in collapsing the outbreak in Santa Clara Canyon.

6. Because large numbers of DFTM caterpillars were actively feeding 25 days after treatment, project effectiveness could not be determined with certainty. Project effectiveness will, therefore, be re-evaluated next spring to determine whether-or-not TM-Biocontrol was effective in reducing DFTM populations to low levels.

Acknowledgements

We would like to thank John Anhold, Arizona Forest Health Zone Leader for assisting us in with our pretreatment larval survey and Stephani Sandoval, (Cooperative Extension Service, New Mexico State University, all the Santa Clara Pueblo Tribal members who helped us with our posttreatment larval, egg mass, and male moth pheromone trapping surveys. We are especially thankful to Imre Otvos, Canadian Forest Service, Natural Resources, Pacific Forestry, B.C, Canada, for conducting the DFTM virus bioassays for us.

Literature Cited

1. Lessard, Gene and David G. Holland. 1985. The use of degree-day accumulation for monitoring Douglas-fir tussock moth populations. Timber, Forest Pest, and Cooperative Forestry Management, USDA Forest Service, Rocky Mountain Region. Technical Report R2-31.

2. Ragenovich, Iral. 2004. 2003 Douglas-fir tussock moth early warning system trapping summary for Oregon and Washington. Forest Health Protection and Air Management Group/National Resources, Pacific Northwest Region.

Appendix A

Sequential Egg Mass Surveys

Twenty DFTM host trees (Douglas-fir and white fir) were randomly selected for sampling. Each tree had to have at least three full-sized lower branches close enough to the ground so that the new egg masses could be easily seen. Egg masses were collected from three lower branches and the number per tree recorded cumulatively on a tally card until a total of 40 egg masses or greater was collected (Figure 1).

Figure 1. 2007 DFTM Sequential Egg Mass Survey Results

No. trees sampled	No. egg masses	Cum. No. egg masses
1	1	1
2	1	2
3	2	4
4	1	5
5	2	7
6	1	8
7	6	14
8	10	24
9	9	33
10	3	36
11	5	41
12	3	44
13	0	44
14	4	48
15	0	48
16	0	48
17	4	52
18	2	54
19	3	57
20	0	57

Predicted defoliation		
L	M	S

Total no. egg masses / No. of trees = 57 / 20 = 2.9 = Heavy

Ave. no. of egg masses per 3 branches = **Total no. egg masses / No. trees**

Ave. number of egg masses per 3 branches	Predicted defoliation
Less than 0.7	light or no defoliation is expected the following year
Between 0.7 and 1.9	moderate but variable defoliation is predicted
More than 2.0	expect severe defoliation, some top-kill and mortality

The total number of egg mass was divided by the total number of trees to predict defoliation using the above predictive table.

Monitoring of Egg Hatch and Timing of Application

In New Mexico, Lessard and Holland (1985) determined that in Los Alamos, NM egg hatch usually occurs near 220 degree-days and that dispersal and larval development were optimal at 500 degree-days from May. Degree-days were calculated as follows:

$$\frac{\text{Max Daily Degree + Min Daily Degree}}{2} - 42 \text{ Degrees F}$$

The threshold temperature for egg hatch for the Douglas-fir tussock moth is 42 degrees F. All plus degree-days values are accumulated. Negative values are treated as zero values and do not enter into the calculation.

The maximum and minimum temperatures for Los Alamos, NM were obtained from the Albuquerque Journal the day after they occurred.

Prespray and Postspray Sampling Procedures

Fifty host trees were sampled within the treatment area. Five trees were sample at ten plots spaced .2 to .4 miles apart along the roadside of Santa Clara Canyon. Douglas-fir and white fir were sampled without preference. The only criterion for tree selection was that they have foliage on low branches that could be reached from the ground. Three 18 inch branch tips were sampled on each tree. Each branch was clipped with a hand pruner and beat around a pole pruner collecting bag to dislodge all the DFTM larvae. Each branch was closely examined and any larvae still on the branch counted. The total larval count from the three branches samples was a sample.

Prespray larval surveys (Appendix A) were conducted on June 13, 2007. Postspray surveys were conducted on June 28, 2007 (15 days after treatment) and on July 9, 2007 (25 days after treatment).

Figure 2. Prespray DFTM Larval Densities

Plot no.	Tree no.	No.per 3 br	Plot no.	Tree no.	No.per 3 br
1	1	7	6	1	17
	2	8		2	7
	3	8		3	7
	4	10		4	26
	5	11		5	16
2	1	25	7	1	3
	2	53		2	7
	3	72		3	1
	4	54		4	3
	5	91		5	2
3	1	22	8	1	2
	2	25		2	0
	3	20		3	2
	4	33		4	0
	5	36		5	0
4	1	142	9	1	1
	2	89		2	2
	3	79		3	1
	4	43		4	0
	5	73		5	1
5	1	17	10	1	0
	2	15		2	0
	3	10		3	0
	4	18		4	0
	5	31		5	0

Figure 3. 15 Day Postspray DFTM Larval Densities

Plot no.	Tree no.	No.per 3 br	Plot no.	Tree no.	No.per 3 br
1	1	16	6	1	22
	2	3		2	22
	3	13		3	1
	4	23		4	2
	5	4		5	1
2	1	29	7	1	0
	2	25		2	2
	3	53		3	0
	4	16		4	1
	5	24		5	1
3	1	57	8	1	0
	2	12		2	0
	3	36		3	0
	4	4		4	0
	5	8		5	0
4	1	5	9	1	0
	2	33		2	0
	3	50		3	0
	4	44		4	1
	5	22		5	0
5	1	22	10	1	3
	2	33		2	2
	3	34		3	12
	4	39		4	4
	5	4		5	0

Figure 4. 25 Day Postspray DFTM Larval Densities

Plot no.	Tree no.	No.per 3 br	Plot no.	Tree no.	No.per 3 br
1	1	7	6	1	8
	2	3		2	1
	3	6		3	7
	4	1		4	6
	5	1		5	2
2	1	0	7	1	7
	2	1		2	24
	3	24		3	7
	4	32		4	7
	5	10		5	6
3	1	6	8	1	23
	2	21		2	12
	3	9		3	2
	4	3		4	13
	5	5		5	20
4	1	12	9	1	14
	2	6		2	3
	3	10		3	0
	4	21		4	8
	5	13		5	1
5	1	15	10	1	1
	2	20		2	8
	3	8		3	4
	4	15		4	18
	5	20		5	8